Further, according to the functional material and the functional device of the present invention, it is possible to change a wavelength of a transmission sound wave such as a transmission ultrasonic wave or convert an incident sound wave into another sound wave whose attribute is different from that of the incident sound wave on the basis of a signal supplied from external.

What is Claimed is:

1. A functional material comprising:

a periodic structure having a periodicity with a unit cycle on the order of a wavelength of an electromagnetic wave; and

means for disturbing the periodicity of said periodic structure, said means being provided in at least one portion of said periodic structure;

wherein said means for disturbing the periodicity of said periodic structure is controllable from external.

2. A functional material according to claim 1, wherein a kinetic function or a change in refractive index is given to said means for disturbing the periodicity by controlling, from external, said means for disturbing the periodicity.

3. A functional material according to claim 1, wherein a first electromagnetic wave incident on said

periodic structure is converted into a second electromagnetic wave, at least one attribute of which is different from that of said first electromagnetic wave, by controlling, from external, said means for disturbing the periodicity.

4. A functional material according to claim 3, wherein said attribute of said second electromagnetic wave is a traveling direction, a wavelength, an intensity, a polarization orientation, a spatial coherence, or a wavelength coherence of said second electromagnetic wave.

5. A functional material according to claim 1, wherein said periodic structure is a one-dimensional, two-dimensional, or three-dimensional periodic structure.

6. A functional material according to claim 1, wherein the unit cycle of said periodic structure is in a range of 1/50 time to 50 times of a wavelength of an electromagnetic wave.

7. A functional material according to claim 1, wherein the unit cycle of said periodic structure is in a range of 1/5 time to 5 times of a wavelength of an electromagnetic wave.

8. A functional material according to claim 1, wherein said periodic structure is formed by stacking, distributing, or building-up elements identical to each other, and said means for disturbing the periodicity is

composed of an element different from said elements constituting said periodic structure.

9. A functional material according to claim 1, wherein said periodic structure is formed by stacking, distributing, or building-up two kinds or more materials, and said means for disturbing the periodicity is composed of a material different from said materials constituting said periodic structure.

10. A functional material according to claim 1, wherein said periodic structure is formed by stacking, distributing, or building-up two kinds or more materials, and said means for disturbing the periodicity is composed of a material which exhibits a kinetic function when receiving a signal from external.

11. A functional material according to claim 10, wherein said two kinds or more materials constituting said periodic structure are dielectric substances.

12. A functional material according to claim 11, wherein said dielectric materials are at least one kind of materials selected from a group consisting of oxides, fluorides, solid-solutions between oxides, solid-solutions between fluorides, chalcogenide compounds, single-semiconductors, and solid-solutions of single-semiconductors.

13. A functional material according to claim 12, wherein said oxides are at least two kinds of oxides selected from a group consisting of TiO2, SiO2, ZrO2, CeO2, Al2O3, MgO, SixOy, ThO2, SnO2, In2O3, ZnO, La2O3, Nd2O3, Sb2O3, Bi2O3, Pr6O11, TixOy, CaO, and SrTiO3.

14. A functional material according to claim 12, wherein said fluorides are at least two kinds of fluorides selected from a group consisting of MgF2, CeF3, LaF3, NdF3, PbF2, NaF, Na3AlF6, LiF, and CaF2.

15. A functional material according to claim 12, wherein said chalcogenide compounds are at least two kinds of chalcogenide compounds selected from a group consisting of ZnS, ZnSe, CdS, CdSe, CdTe, PbS, PbTe, and Sb2S3.

16. A functional material according to claim 12, wherein said single-semiconductors are at least two kinds of single-semiconductors selected from a group consisting of Si, Ge, and Te.

17. A functional material according to claim 10, wherein said material exhibiting a kinetic function is a piezoelectric material or a material having an electro-optic effect.

18. A functional material according to claim 10, wherein said material exhibiting a kinetic function is a perovskite-type piezoelectric material or an ilmenite-type piezoelectric material.

19. A functional material according to claim 18, wherein said perovskite-type piezoelectric material is one kind of perovskite-type piezoelectric materials selected from a group consisting of Pb(ZrTi)O3, (PbLa)(ZrTi)O3, BaTiO3, (BaSrCa)(TiZrSnHf)O3, and PbTiO3.

20. A functional material according to claim 18, wherein said ilminite-type piezoelectric material is LiNbO3 or LiTaO3.

21. A functional material according to claim 10, wherein said material exhibiting a kinetic function is at least one kind of piezoelectric materials selected from a group consisting of Bi12SiO20, Bi12GeO20, Bi12TiO20, KDP, K(TaNb)O3, (SrBa)Nb2O6, ZnO, and (ZnMg)O.

22. A functional material according to claim 10, wherein said material exhibiting a kinetic function is a semiconductor material having no center of symmetry.

23. A functional material according to claim 22, wherein said semiconductor material having no center of symmetry is selected from CdTe, GaAs, InP, ZnS, ZnSe, and these semiconductors are doped with a trace of active metal ions.

24. A functional material according to claim 10, wherein said material exhibiting a kinetic function is a host-guest type inorganic-organic composite material.

25. A functional material according to claim 24, wherein a host of said host-guest type inorganic-organic composite material is an inorganic lamellar material, and a base material thereof is a lamellar perovskite-type niobium containing material, a lamellar perovskite-type copper containing material, a lamellar titanate niobate, a lamellar rock salt structure oxide, a transition metal oxide material, a transition metal oxochloride, a lamellar polysilicate, a lamellar clay mineral, hydrotalcite, a transition metal chalcogenide, zirconium phosphate, or graphite.

26. A functional material according to claim 25, wherein said lamellar perovskite-type niobium containing material is $KLaNb_2O_7$, $KCa_2Nb_3O_{10}$, $RbCa_2Nb_3O_{10}$, $CsCa_2Nb_3O_{10}$, or $KNaCa_2Nb_4O_{13}$.

27. A functional material according to claim 25, wherein said lamellar perovskite-type copper containing material is $Bi_2Sr_2CaCu_2O_8$ or $Bi_2Sr_2Ca_2Cu_3O_{10}$.

28. A functional material according to claim 25, wherein said lamellar titanate niobate is $KTiNbO_5$, $K_2Ti_4O_9$, or $K_4Nb_6O_{17}$.

29. A functional material according to claim 25, wherein said rock salt structure oxide is $LiCoO_2$ or $LiNiO_2$.

30. A functional material according to claim 25, wherein said transition metal oxide is MoO_3, V_2O_5, WO_3, or ReO_3.

31. A functional material according to claim 25, wherein said transition metal oxochloride is FeOCl, VOCl, or CrOCl.

32. A functional material according to claim 25, wherein said lamellar polysilicate is Na_2O-$4SiO_2$-$7H_2O$.

33. A functional material according to claim 25, wherein said lamellar clay mineral is smectite, vermiculite, or mica.

34. A functional material according to claim 25, wherein said transition metal chalcogenide is $TaSe_2$, TaS_2, MoS_2, or VSe_2.

35. A functional material according to claim 10, wherein a conductive material for applying an electric field is formed on both side surfaces of said material exhibiting a kinetic function.

36. A functional material according to claim 35, wherein said conductive material is ITO (In_2O_3 SnO_4).

37. A functional material according to claim 36, wherein said material exhibiting a kinetic function is different in refractive index from said materials constituting said periodic structure.

38. A functional material according to claim 36, wherein said material exhibiting a kinetic function is identical in refractive index to said materials constituting said periodic structure.

39. A functional material according to claim 10, wherein letting A be a thin film made from a conductive material, B be a thin film made from a piezoelectric material or a material having an electro-optic effect different in refractive index from A, C be a thin film made from a paraelectric substance different in refractive index from each of A and B, said periodic structure includes a portion in which said thin films A, B, and C are stacked in the order of ABAC.

40. A functional material according to claim 10, wherein said periodic structure includes a portion in which thin films made from a conductive material are periodically stacked on piezoelectric materials or materials having an electro-optic effect different in refractive index from said thin films made from a conductive material.

41. A functional material according to claim 10, wherein said functional material is formed on a flexible base, to form an artificial skin.

42. A functional material according to claim 10, wherein said functional material is formed on a silicon base, to form an artificial skin.

43. A functional material according to claim 10, wherein said functional materials are two-dimensionally, periodically formed on a base in such a manner as to be separated from each other, to form an artificial skin, and part of said functional materials are deformed on the basis of a signal supplied from external.

44. A functional material according to claim 1, wherein said periodic structure is formed by stacking, distributing, or building-up two kinds or more elements, and said means for disturbing the periodicity includes a material whose refractive index is changed on the basis of a signal supplied from external.

45. A functional material according to claim 44, wherein said material whose refractive index is changed is a polar organic material.

46. A functional material according to claim 44, wherein said material whose refractive index is changed is a liquid crystal material.

47. A functional material according to claim 46, wherein said liquid crystal material is a field alignment type liquid crystal material.

48. A functional material according to claim 44, wherein said material whose refractive index is changed is urea or its associated material.

49. A functional material according to claim 44, wherein said material whose refractive index is changed is carbon disulfide or its associated material.

50. A functional material according to claim 44, wherein said material whose refractive index is changed is a spiropyran based compound, a WO3 based electrochromism associated material, or a photochromism inorganic oxide.

51. A functional material according to claim 50, wherein said photochromism inorganic oxide is LiNbO3:Fe, BaTiO3:Ce, or SrTiO3:Fe.

52. A functional material according to claim 1, wherein said means for disturbing the periodicity is composed of a material deformed by light irradiation or electric field application.

53. A functional material according to claim 1, wherein said periodic structure is composed of a group of dots formed on a base by printing.

54. A functional device comprising:

a periodic structure having a periodicity with a unit cycle on the order of a wavelength of an electromagnetic wave; and

means for disturbing the periodicity of said periodic structure, said means being provided in at least one portion of said periodic structure;

wherein said means for disturbing the periodicity of said periodic structure is controllable from external.

55. A functional device according to claim 54, wherein a pair of said functional devices, each of which has said periodic structure formed by a group of projections periodically disposed on a base, are movably opposed with said group of projections directed inwardly.

56. A functional device according to claim 54, wherein said periodic structure is formed by a group of piezoelectric elements periodically disposed on a base, and those selected from said piezoelectric elements are warped when receiving a signal from external.

57. A functional device according to claim 54, wherein said periodic structure is formed by stacking, distributing, or building-up two kinds or more materials, and said means for distributing the periodicity includes a material which exhibits a kinetic function when receiving a signal from external.

58. A functional device according to claim 57, wherein said periodic structure has a three-dimensional shape having six planes including a pair of opposed planes and electrodes for applying an electric field to said material exhibiting a kinetic function are provided on said pair of planes; and

when light having a broad wavelength distribution is made incident on said periodic structure in parallel to said pair of planes provided with said electrodes, the wavelength of the light passing through said periodic structure is changed by applying an electric field to said material exhibiting a kinetic function by using said electrodes.

59. A functional material comprising:

a periodic structure having a periodicity with a unit cycle on the order of a wavelength of a sound wave.

60. A functional material according to claim 59, wherein a first sound wave is converted into a second sound wave, at least one attribute of which is different from that of said first sound wave.

61. A functional material according to claim 60, wherein said attribute of said second sound wave is a traveling direction, a wavelength, an intensity, a polarization orientation, a spatial coherence, or a wavelength coherence of said second sound wave.

62. A functional material according to claim 59, wherein said periodic structure is a one-dimensional, two-dimensional, or three-dimensional periodic structure.

63. A functional material according to claim 59, wherein the unit cycle of said periodic structure is in a range of 1/50 time to 50 times of a wavelength of a sound wave.

64. A functional material according to claim 59, wherein the unit cycle of said periodic structure is in a range of 1/5 time to 5 times of a wavelength of a sound wave.

65. A functional material according to claim 59, said sound wave is an ultrasonic wave.

66. A functional material according to claim 59, wherein said periodic structure is formed by stacking, distributing, or building-up elements identical to each other.

67. A functional material according to claim 59, wherein said periodic structure is composed of a group of dots formed on a base by printing.

68. A functional material according to claim 59, wherein said periodic structure is composed of a thread-like material.

69. A functional material according to claim 59, wherein said periodic structure is composed of Peltier elements periodically disposed on a base.

70. A functional material comprising:

a periodic structure having a periodicity with a unit cycle on the order of a wavelength of a sound wave; and

means for disturbing the periodicity is provided in at least one portion of said periodic structure.

71. A functional material according to claim 70, wherein a first sound wave is converted into a second sound wave, at least one attribute of which is different from that of said first sound wave.

72. A functional material according to claim 71, wherein said attribute of said second sound wave is a traveling direction, a wavelength, an intensity, a polarization orientation, a spatial coherence, or a wavelength coherence of said second sound wave.

73. A functional material according to claim 70, wherein said periodic structure is a one-dimensional, two-dimensional, or three-dimensional periodic structure.

74. A functional material according to claim 70, wherein the unit cycle of said periodic structure is in a range of 1/50 time to 50 times of a wavelength of a sound wave.

75. A functional material according to claim 70, wherein the unit cycle of said periodic structure is in a range of 1/5 time to 5 times of a wavelength of a sound wave.

76. A functional material according to claim 70, said sound wave is an ultrasonic wave.

77. A functional material according to claim 70, wherein said periodic structure is formed by stacking,

distributing, or building-up elements identical to each other.

78. A functional material according to claim 70, wherein said periodic structure is composed of a group of dots formed on a base by printing, and said means for disturbing the periodicity is composed of a group of dots formed on said base by printing, said material for forming said dots constituting said means being different from that for forming said dots constituting said periodic structure.

79. A functional material according to claim 70, wherein said periodic structure is composed of a thread-like material, and said means for disturbing the periodicity is composed of a thread-like material different from said material constituting said periodic structure.

80. A functional material comprising:

a periodic structure having a periodicity with a unit cycle on the order of a wavelength of a sound wave; and

means for disturbing the periodicity is provided in at least one portion of said periodic structure;

wherein said means for disturbing the periodicity is controllable from external.

81. A functional material according to claim 80, wherein the density of a gas in the vicinity of said means for distributing the periodicity is changed by controlling said means for distributing the periodicity from external.

82. A functional material according to claim 80, wherein a first sound wave incident on said periodic structure is changed from a second sound wave, at least one attribute of which is different from that of said first sound wave, by controlling said means for disturbing the periodicity from external.

83. A functional material according to claim 82, wherein said attribute of said second sound wave is a traveling direction, a wavelength, an intensity, a polarization orientation, a spatial coherence, or a wavelength coherence of said second sound wave.

84. A functional material according to claim 80, wherein said periodic structure is a one-dimensional, two-dimensional, or three-dimensional periodic structure.

85. A functional material according to claim 80, wherein the unit cycle of said periodic structure is in a range of 1/50 time to 50 times of a wavelength of a sound wave.

86. A functional material according to claim 80, wherein the unit cycle of said periodic structure is in a range of 1/5 time to 5 times of a wavelength of a sound wave.

87. A functional material according to claim 80, wherein said periodic structure is formed by stacking,

distributing, or building-up elements identical to each other.

88. A functional material comprising:

a periodic structure containing a material made luminous due to inter-band transition;

wherein excitation light having such a wavelength as to allow said light to substantially pass through said periodic structure is made incident on said periodic structure from external, so that said luminous material is irradiated with said excitation light to allow electrons of said luminous material to be changed from a ground state to an excitation state; and

said periodic structure has a photonic band gap for said emission wavelength allowing emission transition of said luminous material.

89. A wavelength selection light emitting material allowing time setting comprising:

a luminous material made luminous due to inter-band transition, said luminous material being contained in a periodic structure having a periodicity with a unit cycle on the order of a wavelength of excitation light or emission wavelength;

wherein when said wavelength selection light emission material is irradiated from external with excitation light, said luminous material is excited to cause electron transition to an excitation state, and said luminous material is made luminous on a basis of a signal.

90. A wavelength selection light emission material allowing time setting according to claim 89, wherein said luminous material causes the electron transition from a ground state to the excitation state by irradiating said luminous material with said excitation light which substantially passes through said periodic structure;

said periodic structure has a photonic band gap for the emission wavelength allowing emission transmission of said luminous material, to thereby keep a state in which the emission transition of said luminous material is forbidden; and

the shape of a material, other than said luminous material, forming said periodic structure is changed or deformed on a basis of a signal, to disturb the periodicity of said periodic structure, with a result that the photonic field exerting an effect on said luminous material is changed, so that a window of a sharp mobile peak is opened in the photonic band gap, to allow emission transition of only light having a wavelength at the mobile peak of said luminous material.